Siro KURITA* & Chikako IKEBE**: On the systematic position of *Pleurosoriopsis makinoi* (Maxim.) Fomin***

栗田子郎*・池部千賀子**: カラクサシダの分類学上の位置について***

This very small fern, *P. makinoi*, is distributed in Japan, Korea, China and Ussuri of the USSR. Usually the small colony of this plant is found on the damp rocks in woods within the moss-carpets of *Thuidium kanedae* and *Rhytidiadelphus japonicus* in Japan.

The systematic position of this fern is very problematical. It is not fixed yet to what kind of groups of the leptosporangiate ferns the species belongs. For example, Fomin (1934) by whom the genus name of *Pleurosoriopsis* is registered includes this in his subfamily Asplenieae. Similarly Christensen (1938), Ching (1940) and Holttum (1947) treat it as a member of asplenioid ferns. On the other hand, Copeland (1947) put it into his Pteridaceae suggesting the close affinity between *Pleurosoriopsis* and *Anogramma*, and recently Holttum (1973) deals with this as a species of the Hemionitidaceae sensu Pichi Sermolli.

The gametic chromosome number of this fern, n=72, is already reported by Mitui (1970). More recently Masuyama (1975) studies the gametophytes of this species and he suggests very close relationship between this and the members of the Polypodiaceae sensu stricto. In this paper, the present authors report another cytological record in addition to morphology, and discuss the systematic position of this species.

Materials and methods

Used materials were obtained from the Amagi Pass, Shizuoka Prefecture and a bank of Naguri river, Saitama Prefecture. Both somatic and gametic chromosomes were observed in the squash preparations which were treated as follows. To obtain meiotic figures, very young fertile fronds were fixed

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in 1:3 acetic acid-alcohol for 24 hours or longer, and the sporangia alone were squashed in a drop of aceto-carmine. To obtain somatic preparations, intact root-tips were treated with 0.002 mol 8-hydroxyquinoline for 3 hours at 25°C and were fixed in acetic acid-alcohol, for 5 minutes. Then the materials were macerated in 1 normal HCl at 60°C for about one hour and were squashed after the addition of aceto-carmine. The anatomy of rhizomes and petioles was studied by usual paraffin methods, and the size of stomata was measured in the basal part of frond of the adult plants.

Observations

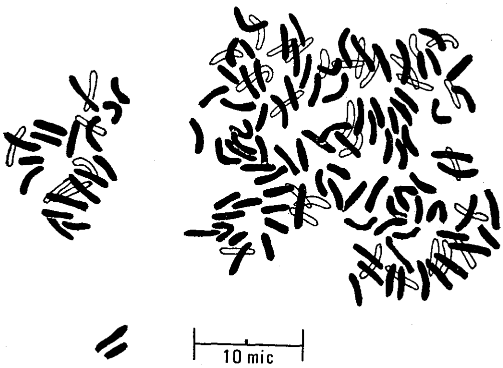

Fig. 1. The metaphase of a somatic cells in the material from a bank of Naguri river, showing 2n=ca. 144.

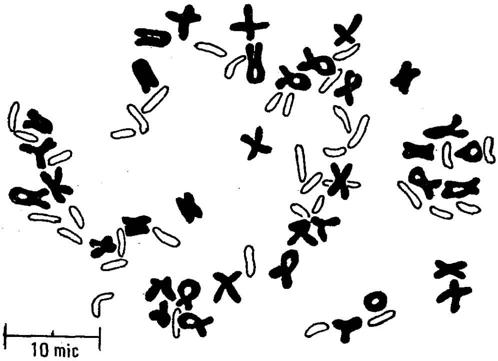

Fig. 2. A spore mother cell in the material from the Amagi Pass, showing 36 univalents and 36 bivalents.

In the material from a bank of Naguri river, a somatic chromosome number of ca. 144 is counted (Fig. 1) and 64 bilateral spores are observed in each sporangium. On the other hand, the course of meiosis of the material from the Amagi Pass is very irregular and consequently 16 spore mother cells in a sporangium give rise to abortive spores which show very aberrant form and number. In some spore mother cells, 36 bivalents and 36 univalents are observed at the first meiotic metaphase (Fig. 2). Therefore the basic chromosome number of *Pleurosoriopsis* is probably 36, thus the plant

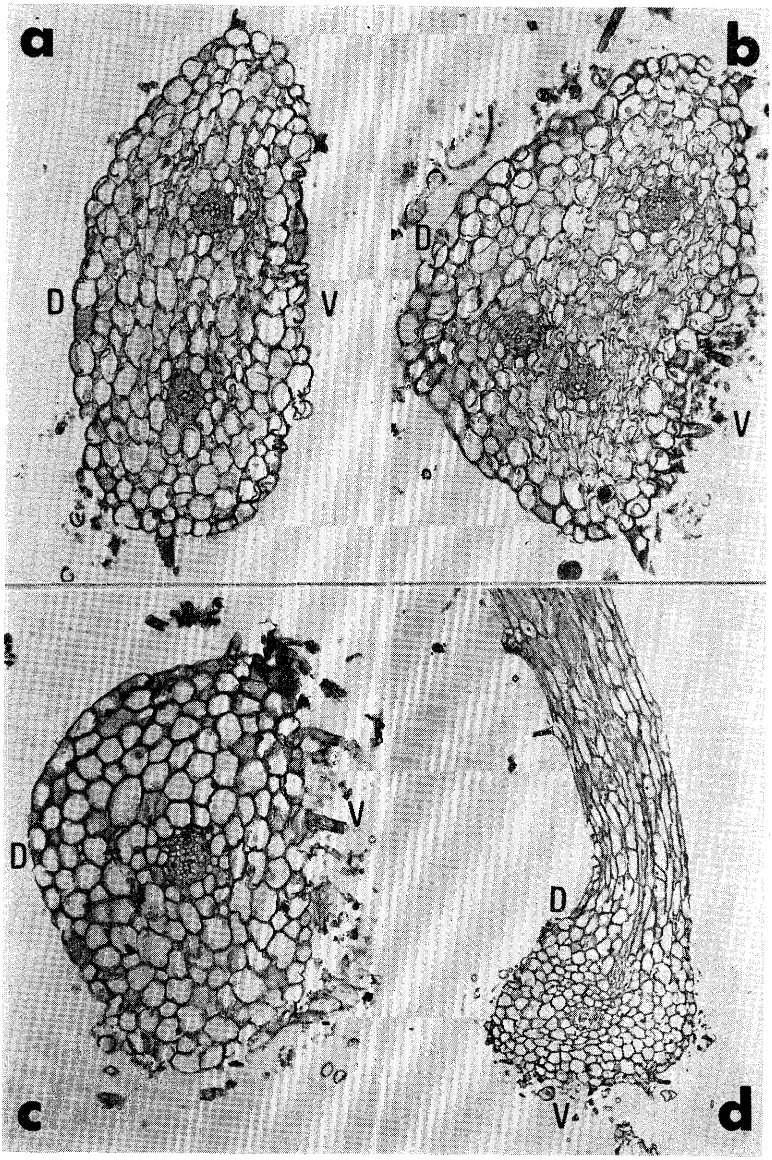

Fig. 3. Cross sections of the rhizome of the tetraploid.
D=dorsal side, V=ventral side. See text.

from a bank of Naguri river may be a tetraploid as well as Mitui's material from Nagano Prefecture, and the plant from the Amagi Pass may also be a triploid race.

Now the authors refer to the other characteristics of this species besides cytology. The creeping rhizomes are somewhat flattened and usually have two rows of meristele bilaterally (Fig. 3-a). At rare intervals these two meristeles are joined by a coupling bundle (Fig. 4-a and 4-c). Usually the fronds which are arranged alternately receive only one leaf-trace from either of the two meristeles (Fig. 3-b, 4-a and 4-b), but it is observed rarely that the derivative bundles from either of the two meristeles unite together and becomes a leaf-trace (Fig. 4-c). While the rhizomes having only one vascular bundle (Fig. 3-c), from which the leaf-trace branches off alternately, are also observed (Fig. 4-d). As shown in Fig. 3-d, there is no distinct structure of articulation in the petiole. Namely the isodiametric cells of rhizome gradually change places with elongated cells of petiole. The scales are only on the rhizome, rather abundant near the shoot-tip. At the basal part of scales there are some rhizoid-like unicellular hairs (Fig. 5). Both surfaces of the rhizome and frond are overgrown with trichomata. The 2-celled hairs which are 100 to 130 μ long by 30 μ to 40 μ wide are only observed on the surface of lamina, and rarely these hairs bear a unicellular appendage (Fig. 6-a). While there are many long multicellular hairs on the rachis

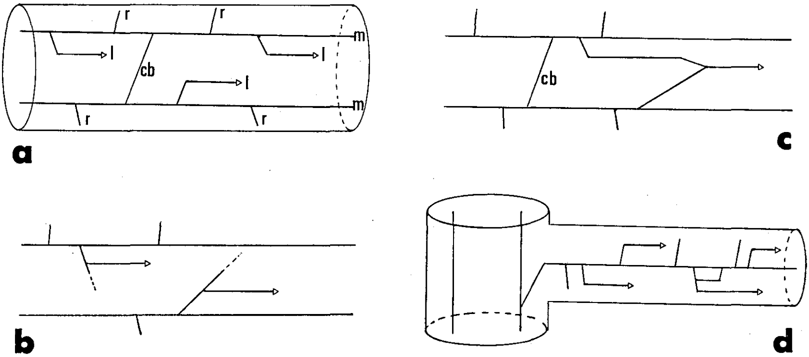

Fig. 4. The schematized vascular behaviour of the rhizome. cb=coupling bundle, m=meristele, l=leaf trace, r=root trace. See text.

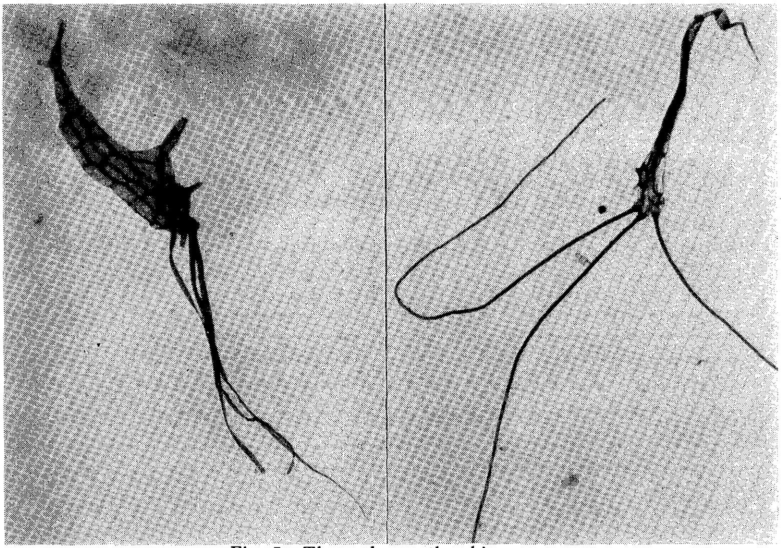

Fig. 5. The scales on the rhizome.

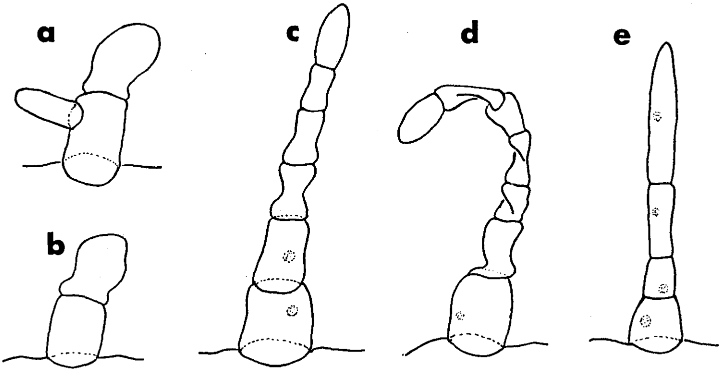

Fig. 6. The multicellular hairs observed on both surfaces of the lamina and rachis.

and around the lamina, and the size of these hairs ranges from 250 μ to 400 μ in length (Fig. 6-c, d and e). In addition to the hairs mentioned above, very peculiar ferrugineous hairs are found on the petiole and rhizome. The majority of them are unicellular filiform hairs which range from 1 mm to 3 mm in length (Fig. 7-a) and these may be a homologue of the

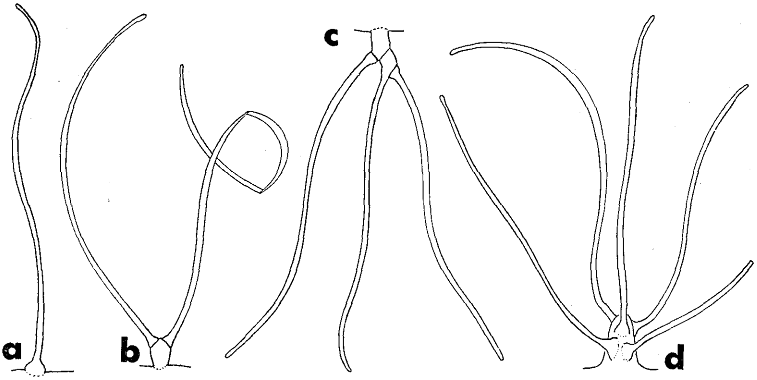

Fig. 7. The very peculiar trichomata on the rhizome and petiole of *P. makinoi*.

rhizoid-like appendages on the surface of scales. The rest is a complex of this unicellular hairs. Namely two or more hairs attach themselves to a basal pivot-like cell or cells as a epidermal protrusion (Fig. 7-b, c and d). The stomatal type of both triploid and tetraploid is "II B" as reported by Kondo and Toda (1956). The size of stomata, however, varies with the level of ploidy as well known. So far as the present investigations are concerned, the mean value ($\overline{X}$) of longitudinal length is 70.2 μ and standard deviation (S) is 4.06 μ in the triploid race. While, in the tetraploid race, $\overline{X}$ is 76.1 μ and S is 4.52 μ.

Discussion

The hypotheses about the systematic position of this monotypic genus *Pleurosoriopsis*, may be divided into three categories. The first opinion, represented by Copeland (1947), is that the genus is closely related to the gymnogrammoid ferns such as *Anogramme*. The second, represented by Christensen (1938), is that it is a member of the asplenioid ferns. And the third which is asserted by Masuyama (1975) is that this species is closely related to the Polypodiaceae sensu Copeland.

At cytological point of view, the phylogenetic relations between this and gymnogrammoid ferns are altogether unimaginable. Because the basic chromosome number of 36 of *Pleurosoriopsis* distinctly differs from that of gymnogrammoid ferns and most of them have the basic chromosome number of 29 or 30. Moreover this basic number, 36, is not found even in the Pteridaceae sensu lato so far known. On the other hand, almost all the species of the Aspleniaceae sensu Alston have the basic number of 36 as well known. In the Polypodiaceae sensu stricto, a little under half the species so far studied cytologically also has this basic chromosome number. Therefore, there is no denying to put *P. makinoi* into the Aspleniaceae or Polypodiaceae. In like manner, however, it also can not be rejected to put this species into other families such as the Grammitidaceae judging from only the cytological point of view.

Apart from cytology, the sporophytic characters of *P. makinoi* are compared with those of the species of other families, the Hemionitidaceae, Aspleniaceae, Polypodiaceae and Grammitidaceae. The very simplified vascular bundle system of the rhizome is peculiar to this species. The authors can not find such a type of vascular bundle in any families mentioned above. But it may be an extremely reduced dictyostele. Almost all the species of the Aspleniaceae and Polypodiaceae have the dictyostele, while the Hemionitidaceae and Grammitidaceae have the solenostele instead. Except the taxa having the protostele, the presence of such a petiole with only one leaf-trace from a meristele is rather uncommon in ferns. In the authors' opinion, however, this may be a simplification attendant upon diminution in plant size.

The cortex area of petioles of almost all species of the Polypodiaceae appears to be composed of two morphologically different types of parenchymatous cells and the abscission zone is formed at the interface of those two cell types (Phillips and white, 1967). According to the authors' investigation, however, there is no definite structure of articulation in the petiole of *P. makinoi*.

The characters of epidermal tissue are often used to determine the affinity between ferns. In this connection, however, the type of stomata is unserviceable to search the systematic position of *P. makinoi* among the families mentioned above, for the type "II B" is found in many species irrespective of the family. However, most of the species of the Aspleniaceae and Polypodiaceae have the "III B" and the "II B" is rather common in the Grammitidaceae and Hemionitidaceae (Kondo, 1962). On the other hand, the non-clathrate scales with some ferrugineous unicellular appendages may be specific to *P. makinoi.* But the scales of some species of the Polypodiaceae such as *Polypodium someyae*, *Neocheiropteris ensata* and *Microsorium pteropus* are somewhat similar to those of *P. makinoi*, and of such species as *Asplenium excisum* and *A. cardiophyllum* also have a resemblance to those of the species. The two-celled hairs on the surface of lamina (Fig. 6-a and b) and the gametophytic hairs which observed by Masuyama (1975) resemble each other in shape, and this sporophytic hairs have something in common with those of *Polypodium formosanum* and *P. someyae.* The multicellular hairs, which are composed of 4, 5, 6, or 7 cells (Fig. 6-c, d and e), are fairly common in the advanced groups of the leptosporangiate ferns. On the contrary, the trichomes which are composed of some ferrugineous filiform hairs and the pivot-like basal cell or protrusion (Fig. 7-b, c and d) are very peculiar to *P. makinoi.* The organizational pattern of this trichome, however, may be comparable with that of the stellate hairs of *Pyrrosia*, a genus of the polypodiaceae.

As mentioned above, the characteristics of epidermal appendages are somewhat suggestive of the affinity between *P. makinoi* and some members of the Polypodiaceae. Moreover, the perineless nature of spores (Sahashi, 1972) and the arrangement of fronds which are restricted to two dorsal rows on the rhizome of this species do not accord with the perinate spores and the spirally arranged fronds of the typical members of the Aspleniaceae (Nayar and Kaur, 1974). While the bipinnate frond with free veins of *P. makinoi* differs distinctly from the simple or pinnatifid frond with reticulated veins and a few free veinlets of almost all the species of the Polypodiaceae.

As to the gametophytic characters of *P. makinoi*, Masuyama (1975) carried out a good study. According to his observations, the gametophytes of this species develop into spatula-shaped one at maturity. Such a type of gametophytes is also known in many families independently, and it is rather common in the Hymenophyllaceae and Vittariaceae. In addition, similar type of gametophytes is also reported in the Polypodiaceae (ex. *Loxogramme salicifolia*), Davalliaceae (ex. *Arthropteris tenella*), Hemionitidaceae (ex. *Anogramma leptophylla*), Aspidiaceae (ex. *Rhipidopteris peltata*), and Aspleniaceae (ex. *Asplenium unilaterale*). And well-developed gametophytes of *P. makinoi* usually have the hairs, composed of two or three cells, with a unicellular hyaline appendage. This hair shows considerable similarity to these of the Polypodiaceae, so he fosters the idea that *P. makinoi* seems to be most closely related to the Polypodiaceae. However, the similar types of hair are also known in the gametophytes of some species such as *Anemia aurita* (Atkinson and Stokey, 1964) and *Ctenopteris asplenifolia* (Stokey, 1960). Moreover, it is very interesting that most of the species which produce the spatulate gametophytes are fundamentally rupicolous or epiphytic ferns as well as *P. makinoi*. Therefore, some of the gametophytic characters of this species are of little use for the determination of its systematic position, if such a nature of gemetophytes is only an analogy or an ecological adaptation to their habitat.

Nevertheless the pattern of spore germination and the early developmental stages of *P. makinoi* are very unique, though Masuyama (1975) recognized them as Gleichenia-type (cf. Nayar and Kaur, 1971). Namely the first and the subsequent walls, parallel to the polar axis of spore, are formed by the same manner as seen in the Gleichenia-type, but the first rhizoid is produced only after the filamental gametophyte reaches four to six-celled stage. This nature is not in accordance with that of the Gleichenia-type in which it is formed by the first cell division. Such retardation on the formation of the first rhizoidal cell under usual condition is only known in the spore germination of the Hymenophyllaceae and the prothallial gemmae of both Hymenophyllaceae and Vittariaceae so far as the present authors' knowledges are concerned. In this species, the initiative cell division of the two dimensional growth of the prothallium is also peculiar. Namely it occurs in the cell second or third from the tip-cell of the filament as usually observed in some of the Aspidium-type prothallial development (Nayar and Kaur, 1971), but the subsequent development differs from that of the Aspidium-type inasmuch as a wedge-shaped cell is formed in the apex of the prothallium in this species (cf. Masuyama, 1975). On the contrary, two dimensional growth in the species which perform the Gleichenia-type germination initiates in the tip-cell, and the type of prothallial development of these species is the so-called Drynaria-type or Kaulinia-type (Nayar and Kaur, 1971).

It may be given as a conclusion that there are no strong and sufficient reasons denying to include *P. makinoi* in the Aspleniaceae at cyto-morphological point of view. However, such characters of this species as the nonperinate spore, non-clathrate scales and the petiolar strand which never shows the X-shape are not in accordance with the general definition of the Aspleniaceae. And also it is sure that there are some similarities between *P. makinoi* and some species of the Polypodiaceae, so far as the characters of the epidermal appendages are concerned. Nevertheless, it may be more suitable to establish the **Pleurosoriopsidaceae** for this species judging from the very specialized or simplified characters of the both gametophytes and sporophytes.

Summary

Two cytological races, triploid (2n=108) and tetraploid (2n=144), are found in *P. makinoi*, so the basic chromosome number of this may be 36. The sporophytic characters of this species are studied, and the nature of the gametophytes which has been studied by Masuyama (1975) is also consulted in search of the phyletic relation. After all, the present authors find no strong and sufficient reasons denying to include or to exclude this species in or from the Aspleniaceae and Polypodiaceae. However, it may be more suitable to establish the Pleurosoriopsidaceae for this species judging from its very specialized or simplified characteristics.

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カラクサシダの染色体数と胞子体の諸形質を観察した。染色体数に関しては$2n=108$の個体と $2n=144$ の個体があり，前者は $b=36$ にもとづく3倍体，後者は4倍体と考えられる。根茎には通常左右2本の維管束が走る。背面に互生する葉が受ける葉跡は1本だけであり，関節構造もみられない。鱗片の基部には単細胞の糸状毛が付着する。この毛は根茎や葉柄にみられる単細胞毛と同質と思われる。また，この単細胞毛の複合体である特異な毛状体がある。

このような特殊化した胞子体の形質や益山により報告された配偶体の形質を考慮すると，チャセンシダ科あるいはウラボシ科に入れることにはいささかの難があり，別に**カラクサシダ科**をたてたほうが望ましいと思われる。

○ヨツバシオガマの白花品（堀井雄治郎） Yujiro HORII: A white flowered form of *Pedicularis*

ゴマノハグサ科ヨツバシオガマ (*Pedicularis chamissonis* Stev. var. *japonica* Maxim.) は北海道本州中北部の高山に生え，かなり広く分布し鮮やかな紅紫色の花をつける高山植物として知られている。しかし，ヨツバシオガマの白花品については未だに記録されていないようである。筆者は岩手県早池峰山にて1971年8月，同1974年7月に純白のものを二度にわたって確認している。早池峯山はヨツバシオガマの白花品の初産地であると考え，岩手植物の会々報12号(1975年)に，*Pedicularis chamissonis* Stev. var. *japonica* Maxim. forma *albiflora* Horii シロバナヨツバシオガマ（新称）として発表した。しかし，この発表では，ラテン記載やタイプ標本の指定がなく正式ではない。関係各庁の採取許可を得て1976年7月にタイプ標本を作成したので次のとおり報告する。最後にこの発表に関して色々と御指導下さった国立科学博物館の金井弘夫氏，岩手植物の会の井上幸三，安本広静両氏に対し謝意を表する。

Pedicularis chamissonis Stev. var. *japonica* Maxim.

forma **albiflora** Horii. form. nov. in Iwate Shokubutsu no Kai, 12: 21 (1975), nom. nud.

Flores albi.

Nom. Jap. Shirobana-yotsubashiogama (nov.).

Hab. Pref. Iwate: Mt Hayachine (Y. Horii, Jul 26. 1976, no. 337463. Typus in TNS).

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